

# Multilocation Annual Ryegrass Cultivar Performance over a Twelve-Year Period

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## ABSTRACT

Systematic performance trials have been conducted in several states for more than 20 yr to evaluate agronomic performance of annual ryegrass (*Lolium multiflorum* Lam.). Despite development and testing of many annual ryegrass cultivars, the first improved cultivar, Gulf, has remained one of 10 to 12 cultivars recommended for planting in the southeastern USA. Our objectives were to evaluate cultivar yield performance across 12 yr at five locations, to assess cultivar yield distribution within growing seasons, and to estimate cultivar yield stability (consistency of relative performance environments). Efficacy measures were early-season yield (total before 1 March), late-season yield (total after 1 March), and total annual yield. Overall means for all cultivars and individual cultivar performance (for common years) were compared with Gulf or Marshall. Neither location effects nor cultivar  $\times$  location interactions were found. Cultivar and year effects, plus cultivar  $\times$  year interactions were detected ( $P < 0.05$ ) for all three yield responses. Mean early season yields ranged from 2.3 to 4.6 Mg ha<sup>-1</sup>, with mean late-season yields ranging from 5.1 to 7.4 Mg ha<sup>-1</sup>. No trend existed for mean total yield relative to Gulf or Marshall to increase over time in association with availability of newer cultivars. Given large yearly fluctuation in yields, it is apparent that unpredictable environmental factors, including climate and perhaps pests, are the primary determinants of annual ryegrass performance rather than differences in yield potential among cultivars. Thus, yield stability may be an appropriate selection factor to include among the criteria for development of improved annual ryegrass cultivars.

**D**URING THE PAST 50 YR, annual ryegrass has become an important cool-season forage plant in the southeastern USA. The development of the first improved cultivar for the region, Gulf annual ryegrass, provided distinct advantages of rust resistance and increased forage yield potential over common annual ryegrass (Weihing, 1963). Development of other cultivars followed, with Marshall being the first cold-tolerant cultivar noted for its superior early spring forage production following particularly cold winter conditions (Arnold et al., 1981). Even though providing major advances, there are recognized limitations with lack of cold tolerance in Gulf (Venuto et al., 1996) and rust susceptibility in Marshall

(Prine, 1991). Prine noted that even though rust caused losses in forage production in the southeast, incidence of rust problems even in susceptible cultivars decreased with widespread planting of resistant cultivars in the late 1960s and 1970s, and subsequently increased with extensive use of susceptible cultivars, such as Marshall, in the 1980s. Although numerous cultivars have been developed and released in recent years, Gulf and Marshall remain the standards for comparison and even serve as a source of material for breeding and selection efforts. For example, 'Surrey' annual ryegrass was developed through selection from Marshall with forage productivity and rust resistance as two of the primary selection criteria (Prine et al., 1989). Likewise, 'TAM 90' annual ryegrass was developed from three parent plants including both Gulf and Marshall with forage yield potential and winter hardiness among the selection criteria (Nelson et al., 1992).

Annual ryegrass is widely adapted in the southeastern USA with an estimated 1.1 million ha grown annually (Evers, 1995). Although reseeding ability has been a selection factor for some cultivars (Prine et al., 1982), most annual ryegrass is planted each year. This large seed demand supports a highly dynamic seed industry. In Louisiana, about 120 000 ha of ryegrass are grown each year. Producer interest has maintained a demand for annual ryegrass cultivar evaluation at multiple sites in Louisiana for many years. Results from these trials are used to develop a list of cultivars recommended for use by forage producers in Louisiana (Twidwell et al., 2003). The procedure used for cultivar recommendation by the Louisiana Cooperative Extension Service for crops with several commercially available cultivars involves testing over multiple years. A commercial cultivar must be tested for three consecutive years with average yield not less than 90% of the 3-yr mean of the top three yielding cultivars. A cultivar is dropped from the recommendation list if it fails to perform satisfactorily, is no longer submitted for testing, or is no longer available to producers in the state.

The need for testing of annual ryegrass cultivars over multiple years was noted by Prine (1991), who stated that an individual cultivar "... may sometimes have one of the highest forage yields in one season and one of the lowest in the next." Prine further stated that evaluations at several locations make possible the selection of the best cultivars for different areas of the southeast. On the basis of this, the Louisiana Cooperative Extension Service has made statewide cultivar recommendations for annual ryegrass. Although extending over a rather narrow range of latitudes, the area of annual ryegrass production in Louisiana ranges from seasonally wet, fertile, clay bottomlands to droughty, infertile, sandy uplands. Although data have accumulated over several years, only the immediate past 3-yr data are used for

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recommendations each year. Any long-term trends in production differences among locations indicated by available data have not been assessed. Trends over time to detect potential relationships of annual ryegrass forage production and such factors as long-term rust buildup as noted by Prine (1991) or improvement in production potential from cultivar development have not been evaluated. Cultivar development has been substantial, with at least 38 different cultivars included on the recommended list during the past 18 yr. Although the list has included only about 10 or 12 entries each year, both Gulf and Marshall have been included every year. The change in other cultivars is associated more with what cultivars were submitted for evaluation than with results of the yield evaluations.

The long-term presence of the original cultivar, Gulf, on the recommended list, raises two important questions about progress of improvement in agronomic performance of annual ryegrass cultivars. Has substantial progress with improvement of yield potential not been made despite selection for this characteristic and release of cultivars identified as more productive from initial tests? Is Gulf perhaps simply a very stable cultivar performing acceptably over a wider range of environments than other cultivars? Cultivar stability includes the rather predictable component of "genotype by location effect" and the highly unpredictable component shown through the "genotype by year effect." An interaction with location can allow superior genotypes to be identified for particular locations as suggested by Prine (1991). Interactions with years are normally associated with such unpredictable factors as weather conditions, pest problems, or management factors which are unintentional and even unrecognized. Determining the stability characteristics may allow identification of locations where Gulf provides yield stability and other locations where cultivars with improved yield potential provide advantages over Gulf.

The overall objective of this research was to determine whether annual ryegrass cultivar recommendations for Louisiana could be improved through more thorough assessment of forage yield over a long time period. Specific objectives were: (i) to compare yield performance among cultivars across 12 yr at five locations in Louisiana, (ii) to assess yield distribution within the growing season, and (iii) to estimate cultivar yield stability (consistency of relative performance across environments).

## MATERIALS AND METHODS

Annual ryegrass performance trials were conducted for 12 yr (1987–1998) at five locations in Louisiana. Performance trials were located at the following sites: (i) Iberia Research Station, Jeanerette; (ii) Idlewild Research Station, Clinton; (iii) Macon Ridge Research Station, Winnsboro; (iv) Rosepine Research Station, Rosepine; and (v) the Southeast Research Station, Franklinton. Respective soil types were: (i) Jeanerette: silty clay (fine montmorillonite, thermic, Vertic Haplaquolls); (ii) Dexter: loam (fine-mixed, thermic Ultic Hapludalf); (iii) Jigger: silt loam (fine silty, mixed, thermic, Typic Fragiudalf); (iv) Angie: very fine sandy loam (clayey, mixed,

thermic Aquic Paleudult); and (v) Tangi: silt loam (fine silty, mixed thermic Typic Fragiudult). Commercial and nonproprietary cultivars as well as experimental lines were included in all performance trials.

The first trial in this study was established in 1986 and the last was established in 1997. Establishment dates for all years were between 20 September and 15 October. All trials were seeded at the rate of 34 kg ha<sup>-1</sup> into a prepared seedbed with an average plot area of 9.3 m<sup>2</sup>. Phosphorus and K fertilizer were applied at all locations according to soil test recommendations. Total N applied was 280 kg ha<sup>-1</sup> in multiple applications of 112 kg ha<sup>-1</sup> at planting and 84 kg ha<sup>-1</sup> following the second and fourth harvests. All plots were harvested from five to seven times each year at each location, depending on weather conditions and growth patterns. Plots were harvested to an average height of 6 cm and the total forage weight per plot was recorded. Samples were collected from each harvested plot and oven dried at 60°C for 3 d to determine dry matter content.

The experimental design for all trials was a randomized complete block with a minimum of three replications. Response variables were early-season, late-season, and total-season yield each year. Early season yield was defined as total forage production from establishment to 1 March, and late-season yield was defined as total forage production after 1 March to the termination of the growing season, which typically concluded in late May to early June. Total-season yield was defined as the sum of early and late-season forage production. Only those cultivars tested for at least three consecutive growing seasons were included in the analysis. Over the 12-yr period, 30 cultivars fell into this category. Since Gulf and Marshall were each tested for the entire period of this study, they were chosen as standards for performance comparisons. For each year, a comparison was made between the combined mean performance of all other cultivars tested and the performance of Gulf or Marshall. Also, individual cultivar performance for cultivars tested in common years was compared to the performance of Gulf or Marshall.

The SAS system for mixed models and regression was used to perform all analyses (Littell et al., 1996). The model was a split-plot model with location, year, location × year, and blocks within location × year as the whole plot and cultivar and cultivar × year as the split plot effects (Cornelius and Archbold, 1989). Location, location × year, and blocks within location × year were considered random effects, whereas year, cultivar, and cultivar × year were considered fixed effects. Response variables in all analyses were total and seasonal forage production. Stability analyses were made in the sense of genotype × environment interactions with a model consisting of entry (genotype), environment (each year at each location), and the genotype × environment interaction for the responses early, late-, and total-season yield. Separate analyses were also made for individual locations with years as environments. The genotype × environment interaction sum of squares and variance were partitioned into two components representing variation within environments and variation between environments. Also, the variance of each genotype was partitioned from the total variance. This variance for each genotype was compared to the variance within environments to estimate stability, which was described in detail by others (Rao, 1970; Shukla, 1972; Bridges, 1989; Littell et al., 1996). The component of variance partitioned for a stable genotype does not differ from the variance within environments. Instability of a genotype is indicated by large differences between the variance of the individual genotype and the variance within environments.

## RESULTS

Statistical analyses revealed no effects of either location or cultivar  $\times$  location interactions. Thus, forage production of cultivars of annual ryegrass in Louisiana over this 12-yr period was not responsive to the more predictable component of genotype  $\times$  environment interaction because of site differences. All three response variables—early season yield, late-season yield, and total-season yield—were affected ( $P < 0.05$ ) by cultivar, year, and the cultivar  $\times$  year interaction. The year effect and cultivar  $\times$  year interaction are in agreement with observed responses of annual ryegrass to such unpredictable factors as amount and distribution of rainfall and temperature extremes. As the cultivar  $\times$  year interaction indicates, cultivar analysis by year for all three response variables results not only in highly variable yield, but in tremendous differences in order or ranking of entries among years. The means (not presented) of 30 entries by 12 yr for the three response variables did not provide readily discernible patterns, as individual entries fluctuated substantially in both yield and rank over the years. Since Gulf and Marshall have been predominant cultivars planted in Louisiana over many years and their responses in the extreme years represent the range of response obtained from the 30 cultivars, comparisons of each of these two entries with the mean of all other cultivars were used to illustrate the variations in responses obtained.

### Total-Season Forage Production

Mean total-season yield across all locations and cultivars ranged from a low of 7.8 Mg ha<sup>-1</sup> in 1996 to a high of 11.9 Mg ha<sup>-1</sup> in 1992 (data not shown). There was no observed trend for total-season yield to increase over time ( $y = 0.07x + 10$ ,  $r^2 = 0.05$ ,  $P = 0.48$ ). Total-season yields did not differ ( $P > 0.05$ ) between Gulf and Marshall, except for 1990, 1991, 1996, and 1997 when Marshall yielded more ( $P < 0.05$ ) than Gulf (data not shown). The greatest observed difference in total-season yield between Gulf and Marshall (2000 kg ha<sup>-1</sup>) was in 1996. Comparison of the total-season performance of Gulf or Marshall versus the mean performance of all other cultivars is presented in Table 1. In only two of the test years (1987 and 1996) did Gulf produce less ( $P < 0.05$ ) total-season forage than the mean of all other entries. Marshall produced more ( $P < 0.05$ ) total-season forage than the mean of all other entries in 1990, 1991, and 1996. Across all 12 yr, total-season forage production of Gulf was not different ( $P > 0.05$ ) from the mean of all other cultivars. Total-season production of Marshall was greater by 472 kg ha<sup>-1</sup> ( $P < 0.05$ ) than the mean of all other cultivars. Performance of these two cultivars across seasons and years, relative to the performance of all other cultivars tested, was highly variable.

Analysis of the total-season yield and seasonal yield distribution of Gulf and Marshall versus each of the other cultivars  $\times$  common years tested is presented in Table 2. A comparison of Gulf versus Marshall revealed greater ( $P < 0.05$ ) total-season forage production for

**Table 1. Forage yield differences between Gulf or Marshall and the mean of all other annual ryegrass cultivars compared by season (early, late, and total dry matter yields) and year averaged across five Louisiana locations. Positive differences indicate a higher yield for Gulf or Marshall.**

Year	Gulf vs. all other cultivars			Marshall vs. all other cultivars		
	Early	Late	Total	Early	Late	Total
	kg ha <sup>-1</sup> dry matter					
1987	-109	-481*	-580*	-149	-65	-204
1988	112	246	370	-67	409*	353
1989	299*	-530*	-231	-227	-204	-431
1990	-501*	-11	-423	673*	449*	1014*
1991	-19	-98	-116	403*	68	471*
1992	530*	-418*	112	-62	329	268
1993	-20	-397	-417	-133	232	99
1994	208	28	236	-378*	521*	143
1995	92	-8	94	-118	-164	-271
1996	-42	-933*	-975*	141	883*	1025*
1997	-174	-140	-314	369*	55	424
1998	399*	-442*	-44	-376*	323	-53
Total	216*	-169*	57	161*	317*	472*

\* Significant at the 0.05 probability level.

Marshall by 402 kg ha<sup>-1</sup>. In addition to Marshall, nine other cultivars produced more total-season forage than Gulf. Gulf only produced more total-season forage than two other cultivars. In contrast, total-season production of Marshall was greater than 12 cultivars and less for none.

These results indicate that Gulf and Marshall are different in total-season forage production when compared directly and when compared to other cultivars tested in common years. Total-season forage production of Marshall was greater than Gulf; however, the mean difference between Gulf and Marshall across all years and locations was only 402 kg ha<sup>-1</sup>.

### Early and Late-Season Forage Production

Mean early season yields ranged from a low of 2.3 Mg ha<sup>-1</sup> in 1996 to a high of 4.6 Mg ha<sup>-1</sup> in 1989 (data not shown). Mean late-season yields ranged from a low of 5.1 Mg ha<sup>-1</sup> in 1995 to a high of 7.4 Mg ha<sup>-1</sup> in 1992 (data not shown). As previously demonstrated with total-season forage production, there was no trend ( $P > 0.05$ ) for early or late-season mean yield to increase or decrease over time. The performance of Gulf or Marshall versus the mean of all other cultivars, for early and late-season yield, is presented in Table 1. Across all 12 yr, early season forage production of Gulf was greater (216 kg ha<sup>-1</sup>) and late-season production was less (-169 kg ha<sup>-1</sup>) than the mean of all other cultivars. Early-season production of Gulf was greater in 1989, 1992, and 1998, and less in 1990 only. However, late-season forage production was less for five of the 12 yr tested (1987, 1989, 1992, 1996, and 1998) and was not greater for any of the years tested. Across all 12 evaluation years, the early and late-season forage production of Marshall was greater than the mean of all other cultivars by 161 and 317 kg ha<sup>-1</sup>, respectively. Early-season forage production of Marshall was greater during 1990, 1991, and 1997, and less during 1994 and 1998. Late-season production of Marshall was greater during 1988, 1990, 1994, and 1996.

**Table 2. Forage yield differences between Gulf or Marshall and each other annual ryegrass cultivar (for common years tested) compared by season (early, late and total seasonal dry matter yields) across five locations in Louisiana. Positive differences indicate higher yields for Gulf or Marshall.**

Cultivar	Gulf			Marshall		
	Early	Late	Total	Early	Late	Total
	kg ha <sup>-1</sup>					
Tetrone	152*	-285*	-122	195*	67	242
Tetila	2	-34	-1	301*	287*	557*
Tetragold	-23	-116	-127	89	251	316
Pennploid V	26	76	96	325*	397*	655*
Florida 80	-54	60	22	-96	533*	435*
Marshall	53	-470*	-402*			
Tetablend 444	64	-135	-57	73	311*	382*
Gulf				-53	470*	402*
Multimo	174*	-380*	-169	217*	-28	196
Surrey	-58	-337*	-381*	-112*	140	27
Nutriblend	166	-356*	-173	209*	-4	191
Magnolia	105	156	262*	325*	423*	719*
Rustmaster	56	-314*	-250*	2	164	157
Dalita	214*	38	269	330*	433*	733*
Jackson	-45	-527	-558	-87	-16	-108
TAM 90	-47	-27	-65	-41	507*	455*
Urbana	133	-657*	-524*	44	-312*	-268
Southern Star	54	-421*	-367*	-152*	182	30
Big Daddy	60	-279*	-220	-8	334*	325*
Rio	47	-538*	-490*	-101	50	-51
WVPBAR-90-300	-15	-187	-202	-47	374*	327*
Abundant	150	-330*	-129	-7	310*	304
Grazer	111	243*	354*	-46	832*	787*
Hurricane	260*	-444*	-184	103	146	248
FL/OR 94LR	130	-452*	-251	-61	228	239
OFI A9	-116	-404*	-521*	47	185	231
Bounty	2	-373*	-372*	-57	249	190
WVPBAR-R-3	107	-276*	-170	47	345*	392*
WAX ME 94	53	-634*	-582*	-7	-12	-19
WVPBARF-11	116	-499*	-384*	103	379*	482*

\* Significant at the 0.05 probability level.

Analysis of the performance of each entry versus Gulf and Marshall, in common years tested for early and late-season yield, is presented in Table 2. None of the entries evaluated produced more early season forage than Gulf, and four of the entries evaluated produced less early season forage. However, Gulf produced more late-season forage compared to only one other cultivar (Grazer) and produced less late-season forage than 19 of the other cultivars evaluated. Early season forage production of Marshall was less than three cultivars and greater than seven. Late-season yield of Marshall was less than Urbana, which was tested in only 4 yr, and greater than 14 other cultivars.

Across all five locations and 12 yr, Gulf produced 53 kg ha<sup>-1</sup> ( $P > 0.05$ ) greater early season and 470 kg ha<sup>-1</sup> ( $P < 0.05$ ) less late-season forage than Marshall. These results indicate that Gulf and Marshall have different yield distribution responses when compared directly and when compared to other cultivars tested in common years. The total-season forage production advantage of Marshall, previously illustrated, is a direct result of its superior late-season production.

### Stability Analysis

Consistency of relative performance across environments is presented in Table 3. Across 60 environments (5 yr  $\times$  12 locations), 13 of 30 cultivars were not stable for early season yield, 14 were not stable for late-season

**Table 3. Stability analysis for early-, late-, and total-season annual ryegrass forage production across five Louisiana locations from 1987 to 1998.**

Entry	Across locations		
	Early	Late	Total
	<i>P</i> value		
Tetrone	0.1	0.01	0.01
Tetila	NS	0.1	NS
Tetragold	NS	0.05	NS
Pennploid V	0.05	NS	NS
Florida 80	0.01	NS	NS
Marshall	0.01	0.01	0.01
Tetablend 444	0.05	0.1	NS
Gulf	0.01	0.01	0.05
Multimo	NS	0.01	0.01
Surrey	0.01	NS	NS
Nutriblend	NS	NS	NS
Magnolia	0.05	0.05	0.05
Rustmaster	0.1	NS	0.1
Dalita	NS	NS	NS
Jackson	0.05	0.01	0.01
TAM 90	NS	NS	NS
Urbana	0.05	0.01	0.01
Southern Star	NS	NS	NS
Big Daddy	NS	0.05	0.05
Rio	NS	NS	NS
WVPBAR-90-300	NS	NS	0.05
Abundant	0.05	0.1	0.05
Grazer	NS	NS	NS
Hurricane	0.1	NS	NS
FL/OR 94LR	NS	0.05	0.1
OFI A9	NS	NS	NS
Bounty	NS	NS	NS
WVPBAR-R-3	NS	NS	NS
WAX ME 94	NS	0.05	0.1
WVPBARF-11	NS	NS	NS

yield, and 13 were not stable for total-season yield ( $P < 0.1$ ). Eight of these cultivars, Tetrone, Marshall, Tetablend 444, Gulf, Magnolia, Jackson, Urbana, and Abundant were not stable for either early or late-season yield. With the exception of Tetablend 444, none of these cultivars was stable for total-season yield.

Stability analysis by location and season revealed few cultivars considered not stable. For total yield, there were no cultivars considered not stable at Rosepine, with one each at Jeanerette (Marshall), Winnsboro (Marshall), and Franklinton (Jackson). Five cultivars (Tetrone, Marshall, Tetablend 444, Gulf, and Rustmaster) were not stable for total yield at Clinton.

### DISCUSSION

The results from this study provide evidence for several consistent responses. Mean total-season forage production of the annual ryegrass entries evaluated showed no significant change during the 12 yr of this evaluation. As older cultivars were dropped from the tests and newer entries submitted, an increase in mean performance of all other entries, relative to Gulf or Marshall, might have been expected. However, this trend was not observed. Thus, newer cultivars may not result in significant yield improvement except for those instances where some particular stress limits yield in a specific environment, such as winter hardiness, disease resistance, or other specific yield-limiting traits that have been targeted for improvement.

Differences in seasonal yield distribution were observed. Although several other cultivars outperformed

Gulf in most years for late-season and total-season yield, no cultivar was observed to repeatedly produce greater early season yield. Although Marshall was not stable across locations and years for early season, late-season, or total-season forage production, it frequently outperformed most of the other cultivars that were evaluated for late- and total-season yield. Given the year-to-year fluctuation in yields, it is apparent that the environment impacts performance to a great extent. Lack of cultivar stability is not necessarily an indication of poor cultivar performance. A cultivar that is unstable may not be a cultivar with poor multiyear performance, but fluctuations in yield among years because of environmental factors alter performance relative to performance of some other cultivars. Instability detected in this research can be attributed to the unpredictable effects among years such as weather, whereas the effects of locations were not substantial.

The variation among cultivars for forage production, observed in this study, supports the need for long-term cultivar evaluation. Data based on two or three years of observation can easily be skewed, relative to the long-term trend, depending on the particular years in which such observations are made. Differences among cultivars from year to year may be a function of several factors, weather probably being predominant. Some of the observed performance differences in annual production can easily be explained by extreme changes in environmental conditions such as occurred during 1996 when the greatest differences in total yield between Gulf and Marshall were observed. An extended period (>3 d) of below-freezing temperatures occurred and severely damaged several cultivar trials (Table 4). On the basis of the freeze-damage ratings taken during 1996, Marshall was one of the least cold-damaged cultivars, whereas Gulf had the highest mean freeze-damage rating. However, there may also be other environmental factors, such as pest problems, that have an influence on relative agronomic performance.

**Table 4. Freeze damage ratings for 19 annual ryegrass entries at four locations in Louisiana in 1996 (adapted from Venuto et al., 1996).**

Brand/Cultivar	Clinton	Franklinton	Rosepine	Winnsboro	Mean
	freeze-damage rating†				
Marshall	0	1	1	2	1.0
Hurricane	0	2	2	2	1.5
Wax ME 94	0	2	2	2	1.5
WVPB-AR-90-300	0	2	2	2	1.5
Jackson	1	2	1	2	1.5
Surrey	1	2	2	2	1.8
OFI A9	2	2	1	2	1.8
Southern Star	1	3	1	2	1.8
WVPB-AR-R-3	1	2	1	3	1.8
Rio	3	2	2	2	2.3
WVPB-AR-F-11	2	2	2	3	2.3
Rustmaster	2	3	2	3	2.5
Grazer	3	3	1	3	2.5
TAM 90	3	3	1	3	2.5
Florida 80	3	3	2	3	2.8
Abundant	3	4	1	3	2.8
Tetablend 444	4	4	2	4	3.5
Big Daddy	5	4	1	4	3.5
Gulf	5	4	2	4	3.8
Means	2.1	2.6	1.5	2.7	2.2
LSD (0.05)	0.7	1.1	0.8	0.8	0.8

† 0 = no damage, 5 = dead.

All of these ryegrass cultivars are open pollinated populations with tremendous morphological variation among individual plants within cultivars (Venuto and Redfearn, 1999). Recent research has indicated that seed size may vary considerably among annual ryegrass cultivars within and among years tested, and this variation in seed size can lead to substantial differences in pure live seed when seeding rates are all at the same weight of seed per acre (Venuto et al., 2002). Higher numbers of seed per unit area can lead to substantial differences in early-season forage production and may mask differences among cultivars for seasonal yield distribution (Venuto et al., 2004).

The transition from grazing warm-season perennial grasses to grazing cool-season winter annuals is usually a period of low forage availability coupled with low forage nutritive value that requires supplemental feeding. To minimize the length of this transitional period, it is important for livestock producers to begin grazing annual ryegrass as early as possible. Considering the usual price differential between Gulf and other cultivars, the early season forage production advantage and the substantially lower price of this widely available public cultivar make Gulf one of the better choices throughout the southeastern USA.

Management practices that maximize early season annual ryegrass production could be beneficial for reducing supplemental feeding. Fall stocker cattle enterprises and lactating dairy cattle could benefit substantially from the early production of annual ryegrass forage. Where animal numbers will not be increased to fully utilize the superior late-season production of some cultivars, the benefit of higher-priced seed may not be realized. Although Gulf is susceptible to cold damage, forage production over a number of years does not indicate that the extent of plant injury from cold was consistently sufficient to reduce forage yields relative to other cultivars. During a 2-yr study, Redfearn et al. (2002) evaluated total forage yield, seasonal yield distribution, and nutritive value differences among six annual ryegrass cultivars. They observed no differences among the cultivars for cumulative forage yield. However, there were differences in the seasonal distribution, with a general decline in nutritive value as the growing season progressed. The most notable differences among the cultivars were the differences in maturity, which resulted in nutritive value differences among some of the cultivars later in the growing season. They concluded that seasonal yield distribution in response to maturity and nutritive value may have been one of the contributing factors to previously observed differences in animal responses among annual ryegrass cultivars. Rather than just yield, which varies more as a result of environmental conditions than cultivar selection, other characteristics that enhance fitness and adaptation, such as forage yield distribution, cold tolerance, and disease resistance, should be included as primary determinants of annual ryegrass cultivar selection in the southeastern USA.

In relation to the specific objectives, yields of annual ryegrass cultivars were highly variable over the 12 yr of this evaluation. Responses of individual cultivars in

absolute yield and performance relative to each other were highly variable from year to year. Location had little effect on cultivar performance. Some cultivars were more frequently among the highest-yielding entries in early season yield, while others were more frequently among the top late-season producers. No entry was among the highest producers in either season during all 12 yr. As these results suggest, lack of yield stability is a characteristic of many annual ryegrass cultivars. Susceptibility of some cultivars to cold damage and diseases such as rust are undoubtedly related to the lack of stability. Since the detected lack of stability is primarily associated with unpredictable year effects, the results obtained do not provide distinct groupings of cultivars into acceptable and unacceptable categories. The results indicate that selection in multiple environments over several years for high yield potential and high levels of stability, rather than selection at a single location, may allow development of an improved annual ryegrass cultivar with superior yield potential under various conditions.

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